THE DEVELOPMENT OF AN OBJECTIVE SCORING SYSTEM FOR EVALUATING MEDITERRANEAN DIET RECIPES

by

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ABSTRACT

The Mediterranean diet pattern has been shown to reduce cardiovascular disease risk. However, it can be difficult to assess or achieve dietary adherence due to a lack of consistent recommendations regarding food quantities and food groups in the pattern. The purpose of this study was to develop a novel objective scoring system to classify Mediterranean diet recipes based on quantities of ingredients. An evaluation of this scoring system was conducted by comparing median nutrient content among recipes (n=300) ranked differently, using the Kruskal-Wallis Test and post-hoc Dunn's Test. Recipes ranked highest rank (Green-light; 67th – 100th percentile) had the most desirable nutrient profile (highest amount of monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), monounsaturated and saturated fatty acid ratio (MUFA:SFA ratio), and potassium), as compared to the medium rank (Yellow-light; 34th – 66th percentile) and the lowest rank (Red-light; 1st – 33rd percentile). The Red-light recipes had the least favorable nutrient profile (highest amount of saturated fat, and lowest amount of dietary fiber, MUFA, PUFA, MUFA: SFA ratio, iron, and potassium) of the three ranks, with regards to the Mediterranean diet recommendation. The scoring system may be further developed as an online consumer application for Mediterranean diet food choices. Moreover, clinical studies are needed to provide an evidence for the efficacy of the system among patient populations.

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CHAPTER 1

INTRODUCTION

1.1 Background

Cardiovascular disease (CVD) is a major public health concern. In 2013, CVD accounted for nearly one-third of deaths in the United States, resulting in approximately 801,000 deaths annually.[1] CVD is associated with an economic burden as well. Specifically, medical expenditures for CVD contributed to an estimated total expense of $96 billion in the United States for the year 2013, not including a loss of productivity that may indirectly impact the economic system.[2] To address CVD risk reduction, the American Heart Association (AHA) and the American College of Cardiology (ACC), have released practice guidelines on lifestyle management.[3] One of the key recommendations for CVD risk reduction is the adoption of healthy lifestyle behaviors, which include a caloric-appropriate dietary pattern that emphasizes intake of vegetables, fruits, whole grains, low-fat dairy products, poultry, fish, legumes, non-tropical vegetable oils, and nuts. Additionally, the guidelines recommend limiting the intake of sodium, sweets, sugar-sweetened beverages, and red meats.[3]

Previously, the relationship between dietary intake and CVD was based on the "diet-heart hypothesis", with the following suggestions: 1) decrease the intake of total fats and 2) replace intake of saturated fats with polyunsaturated fats, preferably vegetable oils with high amounts of linoleic acid.[4] The aim for this hypothesis was to reduce serum cholesterol levels, which was expected to lower the incidence of CVD events and deaths.[4] However, this hypothesis has been challenged in subsequent studies.[5] For example, a recent analysis of data regarding the effectiveness of cholesterol-lowering interventions conducted from 1968 – 1973 showed no evidence of the reduction on the mortality rate from both coronary heart disease and all-cause mortality.[6] An explanation for this lack of evidence could be that an examination of a single food or nutrient would possibly disregard potential synergistic effects of food components and nutrients. Therefore, the approach of evaluating an individual food or nutrient, such as red meat or saturated fat, would then be less predictive of disease risk, as compared with examining overall dietary patterns.[7]

The Mediterranean diet pattern has been validated extensively in both epidemiological studies and randomized clinical trials.[8–10] In a systematic review, Mente et al. reported that adherence to the Mediterranean dietary pattern reduced the risk of developing coronary heart disease by 37%.[8] Furthermore, a meta-analysis of clinical trials by Kastorini et al. showed a significant relationship between Mediterranean diet adherence and improved intermediate factors contributing to CVD.[9] These factors included the following: reduced glucose level, blood pressure, triglyceride level, low-density lipoprotein cholesterol level, waist circumference; and increased high-density lipoprotein cholesterol level.[9] Additionally, another meta-analysis reported that adherence to the Mediterranean dietary pattern was correlated with a decrease in overall mortality.[10]

Descriptively, the Mediterranean diet is characterized by a dietary pattern consisting of mostly plant-derived foods (fruits, vegetables, legumes, grains, nuts, and seeds), with olive oil as a major source of fat; moderate intake of dairy products, fish, poultry, eggs, and wine; and limited intake of red meat.[11] This pattern is traditionally followed by populations in the olive-growing countries and islands surrounding the Mediterranean Sea.[12]

Nutrition interventions incorporating the Mediterranean diet demonstrated positive outcomes that were comparable to other studies on general healthful diets.[13] These outcomes included greater consumption of fruits and vegetables, lower consumption of dietary saturated fats, and a greater level of physical activity.[13] However, these outcomes are reported as short-term changes, with insufficient data to document maintenance over a year.[13] One study conducted by Kuttle et al. evaluated the long-term effectiveness of Mediterranean diet counseling versus low-fat diet counseling in myocardial infarction survivors (n=101) over 24 months of the trial.[14] Results showed that subjects in both groups that could adhere to the intervention had a lower prevalence of disease-related outcomes, as compared with controls receiving usual care. These outcomes included all-cause and cardiac mortality, the incidence of myocardial infarction, hospital admissions for heart failure, unstable angina, and stroke at 24 months.[14]

Despite extensive research, there are no conclusive dietary recommendations for the Mediterranean diet regarding quantities of foods and food groups in the pattern.[15] Several organizations developed and proposed their own dietary recommendations, including the Mediterranean Diet Foundation, Oldway’s Preservation and Trust, and the Greek Dietary Guidelines.[16] Although the main food components are similar, there are several differences in the recommendations for the quantities of foods and food groups in the pattern.[16]

Similarly, there are numerous questionnaires to evaluate the adherence to the Mediterranean diet.[17] Specifically, a review article by Bach et al. identified 24 studies reporting indexes assessing the adherence to the Mediterranean diet. For example, researchers from the PREDIMED study used a validated questionnaire of Mediterranean diet adherence. The questionnaire consisted of 14 questions addressing the serving sizes consumed for each food category. Participants received 1 point if a criterion was met in each category, with a maximum score of 14 points.[18] Alternatively, researchers from the HAPIEE study used the Mediterranean Diet Score (MDS) system for assessing the adherence to the Mediterranean diet. This system consisted of nine food component categories. Participants received 0 – 2 points in each category depending on the amount of food consumed per day, with a maximum score of 17 points.

An alternative strategy for improving dietary adherence is the emerging concept of ‘nutrient profiling.’ The term nutrient profiling is defined as the science of ranking foods based on nutrient composition.[19] Currently, this concept shows promise as an application for the development of nutrition standards, including nutrition labels, health claims, and food marketing/advertising.[20] These applications may help consumers to evaluate food and food products relative to each other within a scheme of a balanced diet.[21] For example, a study from France showed that the application of the nutrient profiling system called “Food Standard Agency nutrient profiling system dietary index (FSA-NPS DI)” score was associated with long-term CVD risk; therefore, the index could be a helpful tool for public health interventions.[22] Several potential applications of proposed nutrient profiling systems include the front-of-pack labeling in England[23] and the reformulation of products in the United States and France.[24]

However, to our current knowledge, there is no integration between the concept of nutrient profiling and the Mediterranean diet in the literature. Therefore, an objective scoring system applied from the nutrient profiling concept that grades food in terms of Mediterranean diet adherence and nutritional profiles is likely to be helpful for consumers. This system may help inform consumers to make appropriate food choices and to adhere to the Mediterranean diet.

1.2 Objectives

The purpose of this study was to develop and evaluate an objective scoring system to classify Mediterranean diet recipes into ranks based on ingredients and nutritional profiles. The hypothesis of this study was that recipes with higher ranks would reveal a better nutritional profile, as compared to recipes with lower ranks.

CHAPTER 2

METHODS

2.1 Development of a Novel Scoring System

This study focused on the development and evaluation of an objective scoring system for Mediterranean diet recipes. Published systematic reviews were gathered from publication databases, including PubMed, ScienceDirect, and Scopus. Investigating keywords included ‘Mediterranean diet’, ‘Mediterranean’, ‘dietary pattern’, ‘adherence’, ‘index’, and ‘score’. For articles, exclusion criteria were as follows: 1) language not in English; 2) content not focused on the comparison and evaluation of Mediterranean diet adherence scores/indexes; and 3) published more than 10 years. For each review article, abstracts were examined. Full-text was reviewed if the article abstract reported the daily amount of foods consumed by participants who adhered to the Mediterranean diet and/or standard portion size for each food participants consumed.

After extensive research, only one published article met the criteria.[10] Sofi et al. proposed a literature-based adherence score to the Mediterranean diet and portion size, with derivation from the calculation based on the systematic review data in the same paper. The standard portion size of foods was documented, including fruit, vegetables, legumes, cereals, fish, meat and meat products, dairy products, alcohol, and olive oil (Table 2.1).

Table 2.1: Literature-based Standard Portion Size of each Food

Foods	**Standard Portion Size (g)**[10]	**U.S. Portion Size Equivalence**
Fruits	150 g	5.3 oz. (1 small apple)
Vegetables	100 g	3.5 oz. (0.55 cup cooked spinach)
Legumes	70 g	2.5 oz. (0.3 cup beans)
Cereals	130 g	4.6 oz. (0.65 cups cooked rice)
Fish	100 g	3.5 oz.
Meat and meat products	80 g	2.8 oz.
Dairy products	180 g	6 fluid oz. (0.75 cup)
Alcohol	12 g	0.4 fluid oz.
Olive oil	N/A	N/A

Next, a target amount of each food to be consumed per day was constructed using a recommendation of daily servings reported by the Mediterranean Diet Foundation.[16] According to the data from What We Eat in America (WWEIA/NHANES) 2013-2014 for the population age 20 and above, Americans consumed approximately 23% of calories during lunch and 35% during dinner.[25] Based on this data, 30% was allocated as the target amount of food per meal. This target number was used for the evaluation of recipes based on the quantity of food ingredient in a serving size (Table 2.2). To note, a target amount was not set for nuts and sweets since there were no data specifically related to the quantity of nuts and sweets consumption reported in the literature gathered. Additionally, a target amount was not established for alcohol since it is commonly consumed with meals, not as a food ingredient. A point system was then developed based on the target amount of food per serving (Table 2.3).

Table 2.2: Dietary Recommendations Proposed by the Mediterranean Diet Foundation

Foods	**Mediterranean Diet Foundation Recommendation[16]**	**Target Amount of Food per Day (g/day)**	**Target Amount of Food per Meal (g/meal)***
Olive oil	Every meal	44 g/day**	15 g/meal (1 tbs.)
Vegetables	≥ 2 servings every meal	600 g/day	180 g/meal (1 cup cooked spinach)
Fruits	1 – 2 servings every meal	450 g/day	135 g/meal (1.25 cup fruits)
Bread and cereals	1 – 2 servings every meal	585 g/day	175 g/meal (0.9 cups cooked rice)
Legumes	≥ 2 servings every meal	20 g/day	5 g/meal (0.2 oz. beans)
Nuts	1 – 2 servings daily	N/A	N/A
Fish/seafood	≥ 2 servings weekly	30 g/day	10 g/meal (0.35 oz.)
Eggs	2 – 4 servings weekly	25 g/day**	10 g/meal** (1/5 egg)
Poultry	2 servings weekly	25 g/day***	10 g/meal*** (0.35 oz.)
Dairy foods	2 servings daily	360 g/day	110 g/meal (0.45 cup)
Red meat	< 2 servings/week	25 g/day***	10 g/meal*** (0.35 oz.)
Sweets	< 2 servings/week	N/A	N/A
Red wine	In moderation and respecting social beliefs	24 g/day	N/A

*Numbers rounded up to the nearest 5 or 10.

**Since Sofi et al.[10] did not report standard portion sizes for olive oil and eggs, the total daily amounts of olive oil and egg consumption reported by Davis et al.[16] were used as target amounts of olive oil and egg consumption.

***Meat and poultry were limited to 50 g/day, and 15 g/meal in total.

Table 2.3: Proposed System for Scoring Mediterranean Diet Recipes

Foods	Target Amount of Foods per Serving (Score = 0 Point)	Target Amount of Foods per Serving (Score = 1 Point)	Target Amount of Foods per Serving (Score = 2 Points)
Fruits	< 67.5 g	67.5 – 134.9 g	≥ 135 g
Vegetables	< 90 g	90 – 179.9 g	≥ 180 g
Legumes/Nuts/Seeds	< 3 g	3 – 5.9 g	≥ 6 g
Refined Grains (RG)	0 g, Refined/Whole Grain ratio ≥ 0.5	Refined/Whole Grain ratio < 0.5	
Whole Grains (WG)	< 80 g	80 – 159.9 g	≥ 160 g
Fish and Seafood	< 5 g	5 – 9.9 g	≥ 10 g
Eggs	≥ 10 g	5 – 9.9 g	< 5 g
Meat and Meat Products	≥ 15 g	7.5 – 15 g	< 7.5 g
Milk	< 1 g, > 108 g	1 – 53.9 g	54 – 107.9 g
Sugar	≥ 7.2 g	< 7.2 g	
Olive Oil	< 7.5 g	7.5 – 14.9 g	≥ 15 g

After the scoring system was developed, sample Mediterranean diet recipes (n=300) were collected from websites via an online search engine (Google®) using keywords (‘Mediterranean Diet’, ‘Recipes’, and ‘Cooking’). Four to five recipes were conveniently selected from each website until the target sample size of recipes was achieved. The amount of each ingredient in each recipe was converted into grams per serving. Similar ingredients in each recipe were allocated into food groups including olive oil, fruits, vegetables, legumes/nuts/seeds, refined grains, whole grains, milk, meat and meat products, fish and seafood, eggs, poultry, alcohol, salt, water, and sugar. These recipes were analyzed based on the food ingredients and were given points based on the recently developed scoring system (maximum score = 20 points; minimum score = 0 points). Points were allocated based on the quantity of ingredient per serving. Recipes were distributed into three tertiles based on points received. Recipes with points in the 67^{h} to 100th percentile were given a "Green-light" rank. Recipes with points in the 34th to 67th, and 1st to 33rd percentile were given "Yellow-light", and "Red-light" ranks, respectively.

2.2 Data Analysis and Evaluation

For each recipe, energy and nutrient contents were analyzed using the Food Processor Nutrition Analysis software (version 10.6.3, 2010, ESHA Research). The analyzed data included energy (kcal), protein (g), carbohydrate (g), fat (g), dietary fiber (g), saturated fat (SFA) (g), monounsaturated fatty acids (MUFA) (g), polyunsaturated fatty acids (PUFA) (g), monounsaturated to saturated fatty acid ratio (MUFA:SFA ratio), calcium (mg), potassium (mg), iron (mg), and Vitamin D (μg), as described in the new U.S. nutrition label.[26] All nutrients were adjusted per 100 kcal of each recipe to account for variability in portion size and caloric content between ranks. Sodium content was not analyzed due to inconsistency regarding the exact amount of salt to be used in several recipes gathered.

Statistical comparisons between each recipe rank were analyzed using STATA software (version 14, 2015, StataCorp.). Due to the non-parametric nature of the data (positively skewed), the Kruskal-Wallis Test was used to compare the difference in median calories and nutrients between each rank. Post-hoc analysis was conducted using Dunn's test to examine the statistical difference between each pair of ranks. (Green-light vs. Yellow-light, Yellow-light vs. Red-light, and Green-light vs. Red-light). Statistical significance was set at p-value < 0.05.

CHAPTER 3

RESULTS

3.1 Food Ingredient Analysis

Among recipes ($n=300$) gathered for this study, 103 recipes were allocated to "Red-light" with the score range of 1-5; 133 recipes were allocated to "Yellow-light" with the score range of 6-8; and 64 recipes were allocated to "Green-light" with the score range of 9-12. With regards to the quantity of food ingredients, no differences in fruit ($p=.18$) and alcohol ($p=.92$) quantity were observed among recipes with different ranks. Green-light recipes had significantly greater amounts of olive oil ($p<.001$), vegetables ($p<.001$), and fish/seafood products ($p<.001$), while containing smaller amounts of refined grains ($p<.001$) and milk ($p<.001$), as compared to recipes in lower ranks. Yellow-light recipes had similar amounts of legumes/nuts/seeds, whole grains, meat/meat products, eggs, poultry, and sugar as Green-light recipes. Red-light recipes had significantly lower amounts of olive oil ($p<.001$), vegetables ($p<.001$), legumes/nuts/seeds ($p<.001$), whole grains ($p<.05$), fish/seafood products ($p<.001$), along with higher amounts of refined grains ($p<.001$), milk ($p<.001$), meat/meat products ($p<.001$), eggs ($p<.001$), poultry ($p<.05$), and sugar ($p<.05$), as compared to recipes in higher ranks (Table 3.1).

Table 3.1: Food Contributors to the Mediterranean Scoring System

Foods	Red-light Recipes (n=103)	Yellow-light Recipes (n=133)	Green-light Recipes (n=64)	p-value
	Median (range)	Median (range)	Median (range)	
Olive oil	2.33* (0, 4.67)	5.25* (2, 9.33)	13.75* (8.87, 21.3)	<.001
Fruits	0 (0, 4.85)	0 (0, 7.63)	1.77 (0, 12)	.18
Vegetables	38.8 * (2.39, 87.85)	90.44 * (33.75, 153.84)	165.72 * (88.06, 249.29)	<.001
Legumes/nuts/ seeds	0 *,** (0, 0)	0 * (0, 15.38)	0 ** (0, 54.65)	<.001
Refined grains	7.81 * (0, 37.8)	0 * (0, 19)	0 * (0, 0)	<.001
Whole grains	0 *,** (0, 0)	0 * (0, 15)	0 ** (0, 44.43)	<.05
Milk	22.89 * (0, 50.83)	0 * (0, 14.18)	0 * (0, 0)	<.001
Red Meat and meat products	0 *,** (0, 60)	0 * (0, 0)	0 ** (0, 0)	<.001
Fish and seafood	0 * (0, 0)	0 * (0, 1.6)	0 * (0, 113.4)	<.001
Eggs	5 *,** (0, 22.22)	0 * (0, 0)	0 ** (0, 0)	<.001
Poultry	0 *,** (0, 0)	0 * (0, 0)	0 ** (0, 0)	<.05
Alcohol	0 (0, 0)	0 (0, 0)	0 (0, 0)	.92
Sugar	0 *,** (0, 5.25)	0 * (0, 0)	0 ** (0, 0)	<.05

*,**,*** significantly different from each other at p < .05

3.2 Nutrient Analysis

Regarding nutrient content, no differences in protein and calcium content among recipes with different ranks ($p = .36$ and $.61$, respectively) were observed. Green-light recipes contained the highest amounts of energy ($p<.001$), MUFA ($p<.001$), PUFA ($p<.001$), MUFA:SFA ratio ($p<.001$), and potassium ($p<.001$), as compared to recipes in lower ranks. Yellow-light recipes had the highest amount of carbohydrate ($p<.001$) and lowest energy ($p<.001$) and total fat content ($p<.001$) among all ranks, with similar amounts of dietary fiber, SFA, vitamin D, and iron with Green-light recipes, and MUFA content with Red-light recipes. To note, Red-light recipes had the lowest amounts of carbohydrate ($p<.001$), dietary fiber ($p<.001$), MUFA ($p<.001$), PUFA ($p<.001$), MUFA:SFA ratio ($p<.001$), iron ($p<.01$), and potassium ($p<.001$), with the highest amounts of saturated fat ($p<.001$) and vitamin D ($p<.001$) among recipes with different ranks (Table 3.2).

Table 3.2: Nutrient Composition of Recipes by Rank

Nutrient	**Red-light Recipes (n=103)**	**Yellow-light Recipes (n=133)**	**Green-light Recipes (n=64)**	**p-value**
	Median (range)	**Median (range)**	**Median (range)**	
Energy (kcal)	352.66 (252.29, 581.36)*	301.51 (220.07, 465.98)*	444.67 (346.37, 557.10)*	< .001
Protein (g/100 kcal)	5.16 (3.38, 7.4)	4.25 (3.15, 6.75)	4.48 (2.72, 6.76)	.36
Carbohydrate (g/100 kcal)	7 (2.72, 10.67)*	10.27 (6.35, 13.7)*	9.145 (3.87, 11.74)*	< .001
Dietary Fiber (g/100 kcal)	0.5 (0.27, 0.96)*,**	1.53 (0.85, 2.42)*	1.47 (0.73, 2.49)**	< .001
Fat (g/100 kcal)	5.43 (4.1, 6.55)*	4.09 (2.86, 6.05)*,**	5.12 (3.91, 6.73)**	< .001
Saturated fat (g/100 kcal)	1.94 (1.13, 2.76)*,**	0.88 (0.5, 1.35)*	0.9 (0.60, 1.11)**	< .001
MUFA (g/100 kcal)	1.7 (1.01, 2.53)*	1.8 (1.16, 3.08)**	3.06 (2.11, 4.16)*,**	< .001
PUFA (g/100 kcal)	0.42 (0.49, 1.61)*	0.45 (0.28, 0.77)*	0.66 (0.44, 0.91)*	< .001
MUFA:SFA ratio	1.05 (1.11, 3.81)*	2.71 (1.12, 4.26)*	3.95 (2.68, 4.84)*	< .001
Vitamin D (ug/100 kcal)	0.06 (0,0.17)*,**	0 (0, 0.03)*	0 (0, 0.04)**	< .001
Calcium (mg/100 kcal)	31.56 (15.48, 56.16)	31.45 (20.44, 47.3)	25.71 (19.38, 46.86)	.61
Iron (mg/100 kcal)	0.63 (0.46, 0.93)*,**	0.79 (0.57, 1.01)*	0.81 (0.58, 1.14)**	< .01
Potassium (mg/100 kcal)	80.54 (38.28, 145.42)*	153.46 (90.07, 237.1)*	203.86 (128.40, 257.6)*	< .001

*,**,*** significantly different from each other at p < .05

CHAPTER 4

DISCUSSION

To our knowledge, this is the first study to integrate nutrient profiling concepts into the development of an objective scoring system to evaluate Mediterranean diet recipes. Previous studies supported the idea that following the Mediterranean diet pattern is likely to improve health outcomes.[8–10] However, the translation of scientific knowledge into practical recommendations for the general population is still challenging. Subjective terms commonly used in recommendations, such as moderation, might create confusion for consumers regarding appropriate dietary choices.[27] Results from the current study indicated that the objective scoring system was able to classify Mediterranean diet recipes into three ranks, based on the quantity of the selected ingredient. Nutrient profiles were improved for the recipes with higher percentiles (Green-light), as compared to the median percentiles (Yellow-light) and lower percentiles (Red-light).

Regarding calories, Green-light recipes had the highest energy content, followed by Red-light and Yellow-light, respectively. Fat content could be a contributing factor to the higher energy content, although fat sources differ ranging from fatty red meat to olive oil. To note, the traditional Mediterranean diet is not promoted as a “weight loss” diet due to a reasonably higher fat percentage than the Acceptable Macronutrient Distribution Range (AMDR) recommended by the Dietary Guidelines for Americans 2015 (DFGA

2015).[28] Therefore, it is expected that the calorie content would increase in relation to the increase in olive oil quantity.

With respect to fat content, Yellow-light recipes contained the lowest amount of fat, with 4.09 g/100 kcal. Green- and Red-light recipes had similar amounts of fat at 5.43 and 5.12 g/100 kcal, respectively. These amounts of fat could be used to infer that the total amount of fat would range from 81.8 – 108.6 g/day, which is 37 – 49% of total calories, for a standard 2000-kcal diet. Both Green-light and Red-light recipes contained greater percentages of calories from fat than the AMDR (20 – 35%), with Yellow-light recipes within the AMDR range.

Specifically, Red-light recipes had the highest amount of saturated fatty acids while Green-light recipes had the highest amounts of MUFA and PUFA. Yellow-light recipes had similar amounts of saturated fat to the Green-light, with MUFA content similar to the Red-light, and PUFA in the middle between Green- and Red-light recipes. According to the American Heart Association (2013), the guideline for saturated fat content[3] is 5 – 6% of total energy intake. Red-light recipes had a higher amount of saturated fat, as compared to the practice guideline, with a median of 17.5% of calories from saturated fat. Green- and Yellow-light recipes had approximately 8% of calories from saturated fat, which was slightly higher than the recommendation. However, the saturated fat percentage from the Green- and Yellow-light recipes was compatible with the amount recommended by the DGFA at <10% total calories[28]. For the MUFA:SFA ratio, it can be clearly observed that the Green-light recipes had the highest ratio, followed by the Yellow- and Red-light recipes respectively, demonstrating that this grading system was able to classify recipes with a significantly different ratio. According to Davis et al., the mean MUFA:SFA ratio for a typical Mediterranean diet is 2.1±0.4.[16] Using the Wilcoxon signed-rank test, ratios were significantly higher than 2.1 ($p<.001$) for the Green- and Yellow-light recipes, and lower than 2.1 ($p<.001$) for the Red-light recipes. Trans-fat was not analyzed due to the minimal amount present in the collected recipes.

Regarding protein, there were no differences in quantity observed among recipes with different ranks. However, there was a significant difference in protein source. Red-light recipes contained a higher amount of meat and meat products, poultry, and eggs, than higher-rank recipes. In contrast, Red-light recipes contained a smaller amount of fish, seafood, and legumes/nuts/seeds than higher-rank recipes. In relation to the daily intake based on the assumption of a median of 4.25 – 5.16 g protein/100 kcal, approximately 85 – 100 g/day of protein is an estimate for a standard 2000-kcal diet. This translates to 17 – 20% of total energy intake from protein, which is within the AMDR.[28]

Red-light recipes contained the least amount of carbohydrate/100 kcal, followed by Green-light recipes, and Yellow-light recipes. This result may be partly explained by the amount of grain quantity because fruit intake did not vary between groups. The amount of carbohydrate ranged from 7 - 10.27 g/100 kcal, which can be extrapolated to 140 (28% of total energy in Red-light recipes) – 205 (41% of total energy in Yellow-light recipes) g/day for a standard 2000-kcal/diet. All numbers within the range are considered lower than the AMDR[28] but were higher than the adequate daily intake level, which is 130 g/day.[29] A trend towards the AMDR was observed in higher-rank recipes. Specifically, Green-light recipes had 75% of total grains as whole grains, while Yellow-light recipes had 53%, and Red-light recipes had only 15%, respectively. This quality concern might also play a role for health apart from the quantity since the DGFA 2015 recommended that more than 50% intake of grains be whole.[28]

When considering dietary fiber, Red-light recipes contained the least amount of dietary fiber/100 kcal, which was significantly lower than the other groups. The median amount of dietary fiber/100 kcal did not differ between Green- and Yellow-light recipes, which was in the range of 1.47 – 1.53 g/100 kcal, or an inferred amount of approximately 30 grams/day for a standard 2000-kcal diet. This number meets the recommendation by the DGFA for women, yet not for men, at 25 and 38 g/day, respectively.[28] However, when reviewing the basis of AI for fiber at 14 g per 1000 kcal intake, as reported in the same DGFA, the number meets the recommendation.

In relation to bone nutrients, Red-light recipes contained the highest amount of vitamin D with the median of 0.06 microgram/100 kcal, as compared to higher-rank recipes at 0 microgram/100 kcal. This finding may be partly explained by the amount of egg (especially egg yolk) and milk/milk products in Red-light recipes. The vitamin D content of a standard 2000-kcal diet, extrapolated based on the observed median of approximately 1.2 microgram/day, still meets only 8% of the U.S. DRI for a person age 9 – 70 years old.[30] Also, the calcium content of recipes did not differ between ranks despite the median quantity of milk and milk products in Red-light recipes as significantly greater than in the Green- and Yellow-light recipes. Median calcium content per recipe was 31.56, 31.45, and 25.71 mg/100 kcal for Red-, Yellow-, and Green-light recipes, respectively. These quantities would translate to an inferred amount of 515 – 630 mg/day calcium intake for a standard 2000-kcal/day diet, which does not meet the recommendation for the U.S. DRI.[30] Strategies to improve calcium and vitamin D intake, such as drinking milk or consuming dairy products, might be needed as a further recommendation. For example, consuming 2 glasses (480 mL) of 2% milk fortified with vitamins A and D would provide 5.76 micrograms/day of vitamin D (~38% DRI) and 576 mg/day of calcium (~58% DRI).[31]

With respect to iron, Red-light recipes contained the least amount of iron (0.63 mg/100 kcal), as compared to higher-rank recipes, despite having the highest amount of meat and meat products. Iron content was similar for Green- and Yellow-light recipes at 0.79 and 0.81 mg/100 kcal, respectively. Therefore, an extrapolated amount of 16 mg/day could be predicted for a standard 2000-kcal diet. This amount meets the standard RDA for men (8 mg/day), yet not for women (18 mg/day) age 19 – 50 years.[32] Strategies to improve iron intake in women age 10 – 50 years, such as increasing consumption of beans and legumes, iron-rich vegetables, and iron-fortified products, might be needed along with continuous monitoring to attain appropriate iron status .

Regarding potassium, Green-light recipes contained the highest amount of potassium at 203.86 mg/100 kcal, as compared to Yellow- and Red-light recipes at 153.46 and 80.54 mg/100 kcal, respectively. Given that the U.S. population aged 2 years or older consumed only 2640 mg/day[33] while the Adequate Intake (AI) is set at 4700 mg/day[34], potassium is a nutrient of concern. From the data analyzed, consuming Green-, Yellow-, and Red-light recipes would yield an inferred amount of 4077, 3069, and 1610 mg/day, respectively, for a standard 2000-kcal diet. Consuming only Green-light recipes for this caloric amount would meet 87% of the recommended AI, although it is 54% higher than the current U.S. actual consumption. However, an interesting point to note is that the DRI recommendations differ between countries. Australia and New Zealand set the AI of potassium at 3800 mg/day for men, and 2800 mg/day for women[35] while the United Kingdom set the Reference Nutrient Intake (RNI) of potassium at 3500 mg/day for adults age 15 years or above.[36] Based on the current data, consuming Green- and Yellow-light recipes (to the total of 3000 – 4000 mg potassium intake/day), based on this proposed scoring system, would not meet 100% of adequate intake for potassium based on the U.S. DRI. However, cardiovascular benefits have been reported in trials where subjects consumed approximately 3247±1432 mg potassium/day (adjusted per 2000-kcal/day).[16] Based on this potassium intake data, consuming Green- and Yellow-light recipes may also yield similar cardiovascular benefits.

In relation to sodium, a conclusive amount of sodium content for each recipe rank could not be determined due to the inconsistency of salt- and sodium-rich foods in the recipes. For this analysis, 118 recipes (39% of total recipes) included the exact amount of table salt, 113 recipes (38%) left the amount to taste, and 69 recipes (23%) did not include any table salt at all. Several recipes also included a bouillon cube or meat/vegetable stock, yet excluded table salt. These discrepancies made a comparison of sodium content in the recipes difficult. Based on the unadjusted data from this study, Green-, Yellow-, and Red-light recipes had a median sodium content of 121.90, 151.12, and 142.67 mg/100 kcal, respectively. Using the Kruskal-Wallis Test, no significant differences were observed between the sodium content of recipes with different ranks ($p=.1297$). Data from the DGFA showed that the U.S. population consumed 3400 mg sodium/day while the RDA is less than 2300 mg/day.[28] Based on this data, strategies to reduce the intake of sodium may be needed. One of the strategies to improve the objective scoring system might include the standardization of all recipes by omitting the added table salt and then recalculating the amount of sodium from the recipe. After standardization, directions to add the table salt specifically to each recipe after cooking, to meet the guideline of less than 2300 mg/day, is a potential recommendation[28].

Results from the evaluation process suggested that the objective scoring system could classify Mediterranean diet recipes into ranks with different nutritional profiles as the outcome. The system could be used for the development of an automated computerized system to evaluate recipes following the Mediterranean diet. This innovative system may be further developed to create online or mobile applications that can provide consumers with information on appropriate food choices and meal planning. Additionally, the applications may serve as valuable tools to increase adherence to the Mediterranean diet.

To note, there are several limitations. First, this study only evaluated recipes. Therefore, further clinical studies are needed to identify whether the adherence to this novel scoring system would result in improved long-term health status. Second, results from this study were specific to the Mediterranean diet pattern. One of the key factors that contributed to increased points in this system was the amount of olive oil in the recipe. By specifically targeting olive oil, other vegetable oils that also have potential cardiovascular benefits[37,38] were not included. Therefore, the use of this system cannot be generalized to other dietary patterns, such as the Dietary Approach to Stop Hypertension (DASH), which have also been shown to be favorable regarding CVD prevention.[39] Nevertheless, the concept and design of this study can be applied to other dietary patterns to create an objective recipe scoring system tailored to those specific recommendations.

CHAPTER 5

CONCLUSION

The objective scoring system developed from this study was able to classify recipes with different degrees of contribution to the Mediterranean diet into ranks. The analysis of the median nutrient content between ranks suggested that the nutrient profiles were more favorable with higher-rank recipes, as compared to lower-rank recipes. Further studies are recommended to evaluate the applicability of the scoring system for patient adherence to the Mediterranean diet pattern.

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